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Review Article

A New Evisceration Technique: The Caging Method

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Introduction

Several evisceration techniques have evolved [1-9]. Stephenson, Kostick, Jordan, Yang, Massry & Holds, Sales-Sanz & Sanz-Lopez, and Huang are some of the modifiers of evisceration techniques. With advancements in evisceration surgery techniques, all modern method can provide better cosmesis and decrease the implant exposure rate. To the best of the author's knowledge, evisceration techniques developed up to this point have aimed to improve only horizontal and vertical excursions. Therefore, satisfaction has been assessed only in horizontal and vertical excursions. Vertical excursions are very limited if performed by these techniques, and oblique excursions are never addressed by these techniques. Indeed, any implant motility without oblique excursions implies incomitance, and if excursions are compared with those of the fellow eye, vertical excursions would be found to be very limited [4,5]. However, currently, patients have increased expectations of enhanced implant motility. Therefore, the purpose of this case series is to present a new technique that provides enhanced implant motility comparable to that of the fellow eye of patients in all excursions. The constructed socket can move horizontally and vertically and can also gaze up and down during adduction. Additionally, in cyclotorsion and Ex cyclotorsion, as well as convergence and divergence, can be observed on the socket if constructed using this technique.

Methods

This single-center study was carried out in a tertiary health facility. A retrospective chart review of data from consecutive patients who underwent surgery with this technique from May 2013 to June 2020 was performed. All surgeries were performed by the same surgeon. The main outcome of this study was enhanced implant motility. Implant exposure was the second outcome measure. Informed consent was obtained from all patients. The Institutional Review Board approved the study. The tenets of the Declaration of Helsinki were followed. The patients were informed about the type of procedure to be performed, and all the patients who underwent this surgery provided their consent. Patient consent was also obtained for the use of figures or video recordings accompanying this paper. After a 360° conjunctival peritomy and opening of Tenon's fascia, the insertion of each of the four recti was exposed. Radial incisions were made from the insertion of each of the four recti up to the limbus. These incisions were joined at the apex of the cornea, and the cornea was divided into four parts with the adjacent anterior scleral shell. The ocular contents were removed. Cauterization of the central retinal artery was omitted to facilitate fibrovascular growth if a hydroxyapatite sphere was preferred. However, if an acrylic sphere was inserted, cauterization was performed. Next, four rectangular scleral flaps were created by making incisions on the inner side of the scleral cavity. These flaps were made in each quadrant between the recti and were left attached to the main shell near the Tilloux spiral. The scleral flaps were then rotated from posterior to anterior on the inside of the scleral shell so that the inner surface of the sclera became the outer surface over the implant. A sphere was inserted into the scleral shell. The flap from the super nasal quadrant was sutured to the flap from the inferotemporal quadrant, and similarly, the remaining 2 opposite flaps were sutured on the previous flaps by using 6-0 polyglactin 910 sutures (Vicryl; Ethicon, Somerville, NJ). Then, the pieces of the cornea were brought closer. The limbal and corneal corners were approached together by incorporating the edges with the same suture material. Therefore, the scleral shell became as if it were a cage. Afterward, the epitel layer of the cornea was debrided. Tenon's fascia was left in place. The conjunctiva was dissected from the underlying Tenon's fascia and pulled over the cornea. In cases of fornix insufficiency, a graft (a pericardial graft or dermis graft) was inserted for conjunctival reconstruction. Sphere size was determined according to the scleral shell capacity. Postoperative follow-up visits were scheduled at 1, 2, 4, 6, and 12 weeks and then every 3 months post procedure.

The technique was developed based on a previous technique defined by Kemal and Kumar [10]. This technique is called the caging technique because it resembles a cage shape. This technique mainly consists of two major steps. The first step involves the construction of the scleral cage for the orbital implant. The second step involves the construction of a socket surface that is resistant to implant exposure. The data of twenty-seven patients with figures or video recordings were analyzed retrospectively. The patients were reviewed based on the presence of implant exposure. Revisions were made by analyzing pictures and video recordings to identify the main restrictive cause and determine necessary revisions. The main restrictive step was in the construction of the scleral cage. In previous cases, if a patient lacked a sufficient scleral shell, it was compensated for, even with a dura mater graft, and the scleral flaps were extended up to even 3 mm near the limbus. Removing the cornea was deemed an unnecessary step. Instead, leaving it in place and making it a more resilient tissue became the second most important step. These are the main stages in which this technique evolved over time. Each stage underwent major revisions and improvements as the surgeon gained a better understanding of the technique, as well as various tips and tricks. All the main steps are shown in (Figure 1).

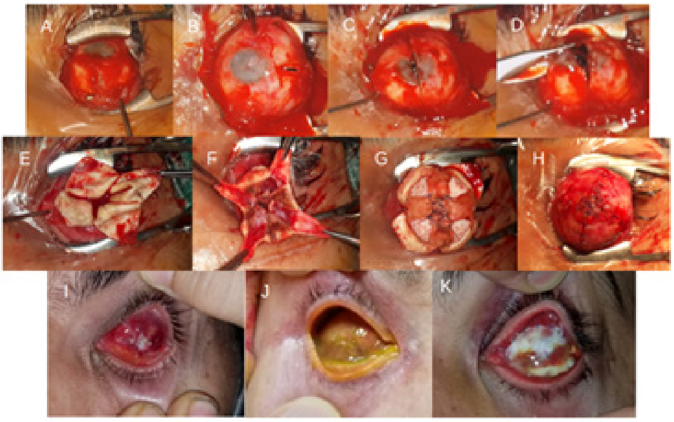

Figure 1: The most important steps of the technique are shown. The best representative figures from several patients were selected from the existing data.
A, B, C, and D show radial incisions made from the insertion of each of the four recti, with these incisions joined at the apex of the cornea.
E- shows the cornea divided into four parts, along with the adjacent anterior scleral shell.
F- shows four rectangular scleral flaps created by making incisions on the inner side of the scleral cavity.
G- shows the flap from the super nasal quadrant sutured to the flap from the inferotemporal quadrant, with the remaining two opposite flaps similarly sutured on top of the previous flaps.
H- shows the limbal and corneal corners approached together by incorporating the edges.
I- show the conjunctiva dissected from the underlying Tenon's fascia and pulled over the cornea.
J- shows another healed socket where the conjunctiva covers the cornea.
K- shows, in another socket, a pericardial graft inserted for conjunctival reconstruction.

The revisions that have been made are as follows:

a) In the previous cases, a hydroxyapatite sphere was preferred; in the latter cases, an acrylic sphere was preferred.

b) When performing scleral flaps in previous cases, the technique strictly adhered to what was defined by Kemal and Kumar [10]. Four rectangular scleral flaps, each approximately 6×12mm in size, were strictly constructed. These flaps remained attached near the limbus (3-6mm away from the limbus). However, a major revision was made. The Tilloux spiral was used as the reference. The scleral flaps were never extended beyond the spiral. In addition, attempts to construct flaps of this size were abandoned. Instead, the length was adjusted by the limit of the Tillaux spiral and according to the capacity of the scleral shell.

c) In previous cases, the cornea was dissected, and the corneal space was reconstructed using a dermis graft. The conjunctiva and Tenon's layer were left in place. A major revision was made in this step. The corneal tissue was left in place, and the conjunctiva was dissected from the underlying Tenon's fascia and then pulled over the cornea. Bringing the conjunctiva onto the debrided cornea provided vascular support to the cornea and transformed the corneal tissue into a fibrovascular, enduring tissue. Revision of this step enhanced the socket's resilience against implant exposure. If pulling the conjunctiva onto the cornea caused fornix contraction, relaxation incisions were made to the bulbar conjunctiva, and the conjunctival defect was closed using a graft. Grafts in such places heal very quickly due to the rich vascular supply in this area.

d) In the previous cases, the sphere size was determined according to the axial length of the fellow eye. Simply put, 21mm was accepted as a benchmark; if the axial length was 2mm less than or greater than 21mm, a 20/22 mm sphere size was selected accordingly [11]. In the latter cases, this criterion was abandoned. Scleral flaps were never extended beyond the Tillaux spiral, and whichever implant size was suitable for scleral shell capacity, was selected.

Implant motility was analyzed in six cardinal gaze directions postoperatively after the first month, as follows: the patient was asked to look in the primary gaze direction at a fixation object and was then instructed to look in six extreme gaze directions (superior, inferior, medial, lateral, superior medial, and inferior medial). Horizontal, vertical, and oblique excursions were determined based on the marked area on the socket surface. The excursions were measured with a standard millimeter ruler. The Bielschowsky head tilt test was carried out to observe in cyclotorsion and Ex cyclotorsion, and the findings were recorded as either present or absent. Subsequently, the patient was instructed to look at a distance point, such as a letter chart. Following this, the patient was instructed to focus on a near point, such as the observer's finger, to observe convergence and divergence. Convergence and divergence were then recorded as either present or absent. The fellow eye was used as the control, and excursions and versions were assessed in comparison to the fellow eye to identify any incomitance. Under motility exceeding 2mm, compared to the fellow eye, was considered indicative of incomitance.

Statistical Analysis

Implant excursions were analyzed to assess whether there were significant differences between fellow eyes and eviscerated eyes. The statistical online calculator 'DATAtab.net' was used to perform the statistical tests. The Levene test was used to assess the equality of variances, and a t-test for independent samples was used to assess the distribution.

Results

Fifteen patients were found to adhere to the sufficient criteria for inclusion in this study. These patients are those who have not developed implant exposure and are deemed to have sufficient modifications according to the mentioned revisions. Among the 15 patients, 8 (53,33%) were male, and 7 (46.67%) were female. The median patient age at the time of surgery was 42 years (range: 16-74). All the patients were followed up for a minimum period of 12 months, and the median duration of postoperative follow-up was 14 months (range: 12-35 months). The indications for surgery are traumatic phthisic eyes and eyes that underwent multiple surgeries resulting in absolute glaucoma and corneal decompensation. A hydroxyapatite sphere or acrylic sphere was placed in each eye.

Implant Motility

The mean motility in the superior, inferior, medial, lateral, gaze-up in adduction, and gaze-down in adduction directions are shown in Figure 2. Implant motility was not significantly different between fellow eyes and eviscerated eyes in any of the excursions ($p \leq 0.05$): t(28) of superior excursion = 0.57, p = 0.572 with a Cohen's d of 0.21; t(28) of inferior excursion = 0.78, p = 0.439 with a Cohen's d of 0.29; t(28) of medial excursion = 1.21, p = 0.235 with a Cohen's d of 0.44; t(28) of lateral excursion = 0.86, p = 0.403 with a Cohen's d of 0.31; t(28) of gaze up in adduction= 0.86, p = 0.399 with a Cohen's d of 0.31; t(28) of gaze down in adduction = 0.86, p = 0.395 with a Cohen's d of 0.32. In addition to the horizontal and vertical rectus muscles, oblique muscles were found to act. In cyclotorsion/Ex cyclotorsion and convergence/divergence reflexes were maintained in all the patients (Figure 2).

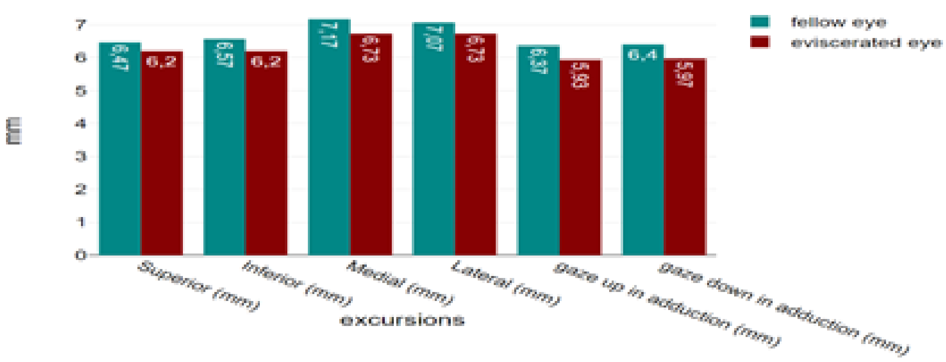

Figure 2: Graph showing the mean motility of the fellow eye and eviscerated eye in six cardinal gaze directions. Implant motility was measured in millimeters.

Supplementary video 1: Supplemental digital content demonstrating the implant motility of patient 7, formatted in mp4 named begin and end.

As an example, Video 1 is available as online-only material and demonstrates the implant motility of one of the cases (see online supplementary Video 1).

Discussion

Techniques that use anterior transposition of scleral flaps change physiological dynamics [8,11,12]. Anterior transposition tightens the rectus muscles and works as resection on agonist and antagonist muscles simultaneously, and these muscles begin to counteract each other. Therefore, excursions in the muscle direction will be restricted [13]. Additionally, the anterior forward of especially vertical extraocular muscles affect the check ligaments and may result in ptosis [14]. Furthermore, forward displacement of flaps loosens oblique muscles and disables them. To the best of the author's knowledge, there are no reports on the continuation of working oblique muscle motility in an eviscerated eye in the literature yet. Additionally, due to the disturbance of orbital anatomy, the maintenance of convergence and divergence has not been mentioned in any report. The essence of this technique is filling the orbita close to the anatomical position. The extraocular muscles resume action in the nearest physiological position, so the implant acquires motility in all excursions as the capacity of the extraocular muscle allows. The oblique muscles and convergence and divergence reflex resume action in addition to vertical and horizontal excursions. To date, this technique is the only reported technique that gives the socket this degree of mobility. Although the main opinion about this technique is based on the letter of Kamal and Kumar, it requires several revisions [10]. Kamal and Kumar mentioned in their letter the construction of four rectangular scleral flaps, each approximately 6×12mm in size. This provided a useful guide for inserting the implant close to the anatomical position. However, solely relying on this knowledge does not ensure the stability of the sphere in its place. The development of a decent evisceration technique that is resilient to implant exposure and enhances implant motility by maintaining the implant close to the anatomical position requires much more experience and revision than what Kamal and Kumar's work provides. Nevertheless, the author acknowledges their help. The surgeon did not know how a sphere could pass through a narrow limbal area, and four rectangular scleral flaps could not cover the anterior side of the sphere completely. To develop a feasible technique, the surgeon made several modifications. For an appropriate implant size, relaxing incisions should be made radially in four regions from the insertion of each of the four recti muscles up to the apex of the cornea to expand the scleral shell in front of the equator. While preserving corneal tissue is a revision, this alone is not enough. Making it resistant to exposure requires additional adjustments. Debriding the corneal epithelium facilitates conjunctivalization when covered by the conjunctiva. Additionally, forward displacement of the conjunctiva requires graft insertion. Implementing these changes demands experience, and they differ from what Kamal and Kumar teach. Therefore, the author attributed this technique to the surgeon and named it the caging technique.

Although there are no reports in the literature on the most effective technique against implant exposure, the general bias is that the techniques that use the scleral petals anteriorly to cover the implant are the most effective [12,15]. Massry & Holds and Sales-Sanz & Sanz-Lopez used this method [4,5]. Although they reported no cases of implant exposure, Masdottir & Sahlin and Smith reported implant exposure rates of 5% and 1.49%, respectively, in their large series [16,17]. The patients in this series were selected from those who had not developed implant exposure based on the defined criteria. This means that if evisceration surgery is performed according to these defined criteria, implant exposure will never develop. Therefore, it can be argued that this technique is as effective as previous techniques against implant exposure. The main limitations of this study are its retrospective nature, absence of a control group with any other technique, small sample size, single-center nature, and potential selection bias. Addressing these limitations through a prospective, controlled study with a larger sample size is beyond the ability of any single surgeon. Multicenter collaboration is needed. The main strength of this study is its presentation of a novel surgical technique aimed at enhancing implant motility in eviscerated eyes. This technique appears to address a significant gap in existing evisceration techniques by providing enhanced implant motility comparable to that of the fellow eye in all excursions. Additionally, the study demonstrated the efficacy of the technique through a detailed description of the surgical procedure, retrospective analysis of patient outcomes, and documentation of implant motility in various gaze directions. Furthermore, the study offers insights into the evolution of the technique through revisions and improvements made over time, demonstrating a commitment to refining surgical approaches based on clinical experience and outcomes. The inclusion of video recordings and figures enhances the understanding of the surgical technique and patient outcomes, adding depth to the presentation of results. This technique enables the implant to be in the place where previously intraocular tissue resides and provides a promising option for patients seeking improved implant motility and cosmesis. In conclusion, this technique allows the placement of a sphere close to the anatomical position and avoids disturbing any extraocular muscle insertion, direction, or strength. The check ligaments and suspensory ligaments remain uncompromised. In the Tillaux spiral, the pulleys are preserved despite the insertion of a sphere. This is closely associated with physiological three-dimensional Tenon's capsule-pulley reconstruction. These pulleys are dependent upon the intermuscular septum and Tenon's fascia for their support and are believed to be the functional origin of the muscles [18,19]. Once the sphere becomes a fulcrum for the tenon, suspensory ligaments, and extraocular muscles, the implant gains maximum extraocular movement, including oblique muscles. Implant motility can reach levels approximately similar to those of fellow eyes in patients in all versions without incomitance.

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

While preparing this work, the author used ChatGPT 3.5, Grammarly, and Curie to check punctuation, syntax errors, and the flow of the phrases. The author edited the content as needed. After using this tool, the author reviewed and edited the content as needed and took full responsibility for the publication's content.

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